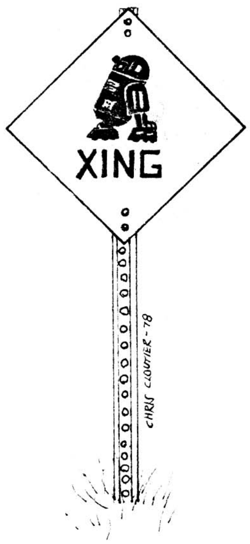
Jeff Duntemann's Chaotic Manual of Robot Assembly

A PyroTechnics PUBLICATION



BUILD A ROBOT!

INTRODUCTION: I realize this booklet is chaotic. It says so right on the label. Call it an experiment in methods of organization. Having worked with robots for a couple of years now, I simply sat down and wrote out everything I could think of about robots; things I had learned the easy way or the hard way, things other people had learned and told me about, or things I had read. It's a big field that doesn't easily lend itself to a neat outline with a progression of thought from theory to practice to final execution of a robot, up, running, and minus all bugs. I found that non-organizing my material this way made things a good deal more compact--you'd be appalled to learn just how much verbiage is wasted forcing continuity upon essentially discontinuous fields of endeavor. In short, there is no pattern here. To get what you want you'll have to read the whole thing. Do like the college kids do and highlight your favorite parts with a bright pink magic marker.

Better still, read the whole thing, and then build a robot, or even half a robot. Then you'll know as much about it as I do, and I can start asking you questions.

BUILD CHEAP, BUILD AVAILABLE: Stop and look around you. That's your robot, all over. The original Cosmo Klein had an upper plate made out of scrap plywood, supported over the lower plate by three sections of ancient brass shower curtain rod. The lower plate was a circular sink-top cutout; a sort of composition doughnut hole left over when the remodelling places mount sinks in powder-room counters. They can be had for a couple of bucks, they're pretty, and they'll support several hundred pounds, which is too damned heavy for a robot. A goodly number of his parts had once seen service in office copy machines, broken but reworked. The greatest triumph of scrounge lay in Cosmo's upper housing, which--believe it or not-- is the cast aluminum frame from a WWII Navy submarine sonar console. I bought it at a junk auction just to be silly. The auctioneer shouted, "Who'll offer me a quarter for this gem?" "I will!" I shouted, expecting roars of laughter and at least one more joke bid. Nobody laughed. Nobody bid. And the goddamned thing sat in my closet for three more years until one day I looked cross-eyed at it and realized it would make a dynamite robot body. Listen to your subconscious. It's not "junk." It's a potential robot. So there.

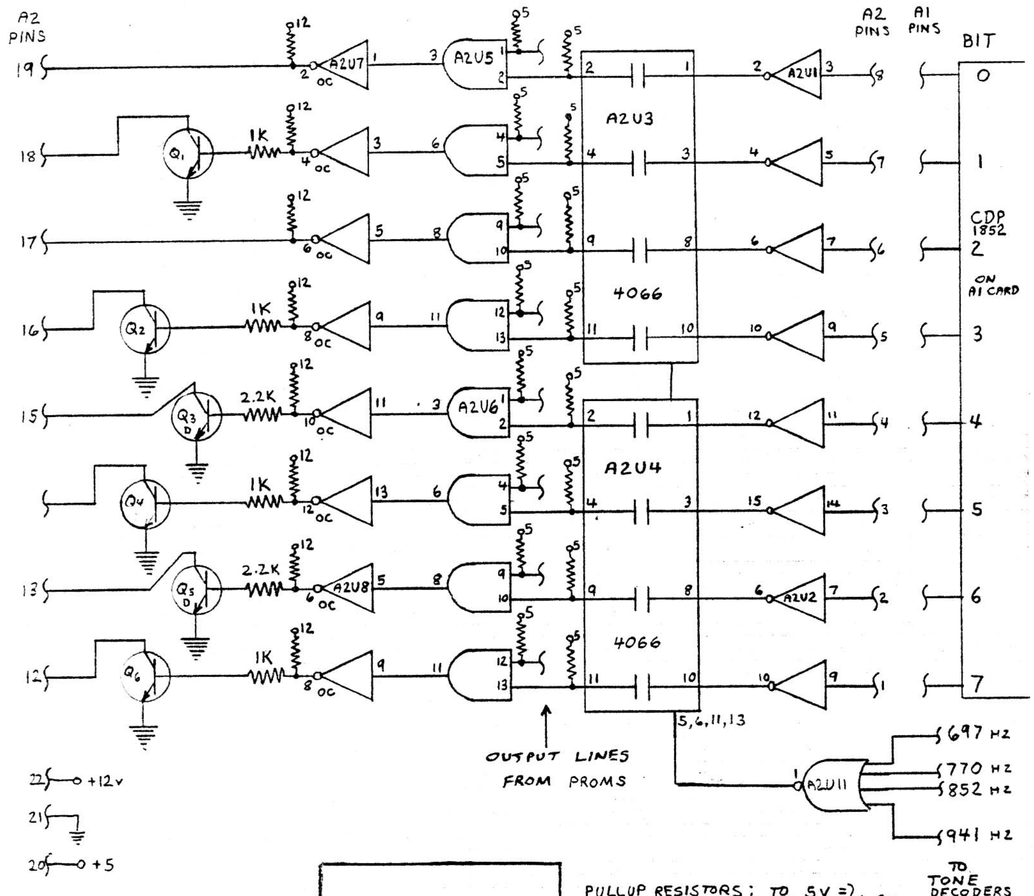
WHERE TO GET ROBOT MOTORS: At this writing (July 1978) the very same motors which power all General Technics robots, from Joe through BEMO-I through Cosmo Klein, can be had from Fair Radio Sales, 1016 E. Eureka Box 1105 Lima Ohio 45802. Write to them for their catalog, as availability and prices will probably change.

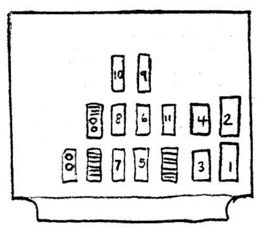
KEEP YOUR CENTER OF GRAVITY LOW: One reason Cosmo Klein was so short and squat was that Joe was so tall and skinny. The famous night we all took Joe to Dunkin Donuts, his right wheel slipped into a piddling little pit in the sidewalk that wouldn't even have tripped a drunken patronage worker, but over Joe went on his side, earning a dent that remains with him to this day. I lowered Cosmo's CG by cutting a car-battery- sized hole in his base plate and slinging the battery down on aluminum straps until it got within half an inch of the third wheel. Careful planning of battery and wheel mounting could bring the battery down within a couple of inches of the ground. Since at least three quarters of your robot's mass is going to reside in the battery, get that thing down as low as you can go. Don't worry about the battery striking objects. If it's tall enough to hit the battery, it's too damned tall for your robot to be running over it. Learn how to steer, or give him better sensors.

STORAGE BATTERIES FOR ROBOTS: Joe and Cosmo use identical batteries, a JC Penney maintanence-free model intended, I believe, for Pintos. Its most valuable feature is the nature and location of its terminals. They are on the side, instead of on top, and have screw-in contacts using a heavy half-inch fine-thread machine bolt. For robots, at least, this is infinitely better than the ubiquitous plain lead stud terminal. The Penney battery does not require water periodically, but it is not a "sealed" battery, like a Gel-Cell or some of the newer cadmium car batteries. It has little gas vents on top that will leak acid in dribbles if you invert or seriously tip the battery. If your robot tips over, get him up fast! If at all possible, use a sealed battery. Vented batteries release gas which can be slightly corrosive, and I am seriously concerned about the state of some of Cosmo's wire-wrap joints. The silver plated wire is in places quite black, and intermittent joints in microprocessor circuits are murder to track down. Then again, use what you have, and a dirty old car battery for free is always better than no battery at all. Another source to be investigated is the American Science Center, 5700 N. Northwest Highway, Chicago IL 60631. They have 10 amp/hr storage batteries for $9.50 each, and two of those are everything a Cosmo-type robot could need. I'm not sure if they're sealed or not, but the price is certainly right. Get their catalog and ask about the batteries. The best way to charge a car battery is to use a commercial charger, new for maybe twenty bucks, or often at flea markets for much less. Components for handling five and six amp currents effectively are not common, so building one might be more time and money than it's worth. I doubt you'd save much.

THE THREE-LAYERED NERVOUS SYSTEM PHILOSOPHY: There are three levels of electrical control in a robot, and you should design them carefully so that control priority extends from the bottom up. Bottommost layer of control is your power switches and fuses. Make sure there is no power path which is not fused. Middle layer is manual control. In this layer lie your radio tone decoders and override interface. A good robot should be able to operate with just these two layers as a remote-controlled truck, like Joe and Cosmo with his submarine console removed (In his "ottoman mode," we might say.) Top layer is your microcontroller. Normally this does all the "thinking," but your override interface should enable you to take over motive controls immediately should your pride-and-joy start heading for an open manhole. Circuit diagram 2 gives Cosmo Klein's override interface. Cosmo is set up so that his motor controls could take orders from any 8-bit output port. Of course, if you use more than four DC reversible motors in your robot, you'll need more output ports, and override becomes more complicated. But I haven't gotten that far yet.

MOTOR DRIVER LOGIC CARD A2





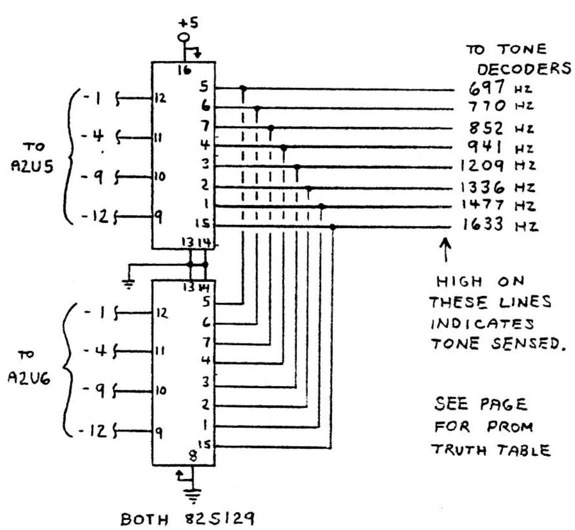
Q_1 Q_2 Q_4 Q_6 = 2N3904
Q_3 Q_5 = MPS A13

PULLUP RESISTORS: TO 5V = } 6.8K
TO 12V = }

A2 U1, A2U2 = CD4049
A2 U3, A2U4 = CD4066
A2 U5, A2U6 = 7486 XOR GATES
A2 U7 A2U8 = 7406
A2 U9, A2U10 = 82S129
A2 U11 = 4002

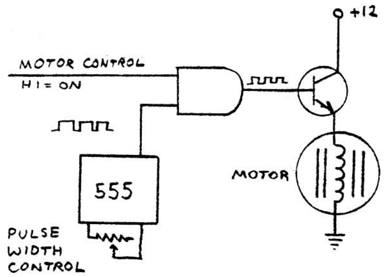
SPEED CONTROL: Don't try to control your speed by biasing your motor driver transistors into their active region. This is a nice simple method. A very small varying current in the base circuit will control a very large varying current in the collector circuit. One catch: power transistors dissipate enormous amounts of power when operated in their active regions. So much that a typical power transistor, poorly heat-sunk by a fumble-fingered hobbyist, will normally cook itself in short order. Your driver transistors should be either cut off (not conducting) or saturated (running the motor at full speed.) If you must control speed, do it by pulse-width modulation. AND your motor control line together with pulses from a 555 timer, and arrange to vary the width of the pulses from the timer. The wider your pulses, the more energy will be delivered to the motor, and the faster the motor will run. Your drivers will not overheat. Take care so that the rapid rise-time of the pulses does not generate hash to interfere with your radio controls. Operating at VHF usually prevents this.

USING STEPPER MOTORS IN ROBOTS: This is a great idea. Unfortunately, I have no idea where to get stepper motors at any price. If any reader knows where to get stepper motors, please let me know.



BOTH 82S129

MOTOR SPEED CONTROL



I HAVE NOT TRIED THIS YET, BUT IT HAS BEEN DONE

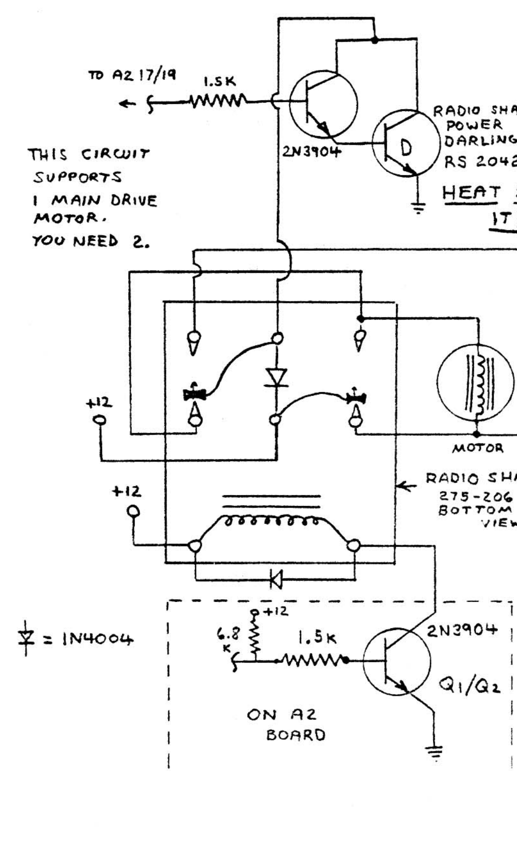
RADIO CONTROL FREQUENCIES: Generally, you have two ways to go. First and easiest, you can operate on CB. Buy a kiddie-talkie and patch a miniature tone-pad into the transmitter input. This is easier than it sounds, since most tone-pads have low-impedence outputs and can be put right in parallel with the speaker/mike. Put a CB set in your robot and run the earphone output to your tone decoder board. This system has a few problems. If somebody else gets on your control channel, your robot will start doing the damndest things as it tries to obey the shreiks of interference heterodynes as though they were touchtone tone pairs. Messy. Also, people will accuse you of "throwing carriers" and "making funny noises." I'd call most CB traffic "making funny noises" these days, so don't get paranoid. But constant interruptions are irritating. A much better method is to get a Technician's amateur radio license and control your robot on the 2-meter band. (144-148 Mhz.) There are about a hundred times as many channels to choose from, most of which are used seldom, if ever. Also, many 2-meter handie-talkies have built- in touchtone pads, and thus are powerful, handheld control boxes, finished and ready to use without further tinkering. 2-meters, in the VHF region, is much less prone to static and interference from electric motors, microprocessor clock generators, and renegade electric toothbrushes. Also, on FM there are no shreiking heterodynes from co-channel interference. The strongest signal on the channel "captures" the channel, so if your frequency gets "captured" by somebody else, your robot stops and you just wait it out. But take it from me, that doesn't happen very often. On 2 meters you have all the room in the world. Get into ham radio--you'll be glad you did. So will your robot.

STEERING PHILOSOPHY: You can steer a robot either by using 2 motors and controlling them independently, or by using a single motor driving the rear axle and turning a front steering axle by gear or pulsed solenoid/ratchet wheel. What many people forget is that the second method requires a differential. A differential is a funny little rotating gearbox in the middle of a driven axle. It distributes constant torque at varying speeds to the two drive wheels. The reason is almost obvious. When the robot goes around a corner, the inside driven wheel goes a good deal slower than the outside driven wheel. The two wheels would have to fight it out, since they are presumably mounted on the same axle, and stutter and scrape over the ground. This is dumb. I'm at a loss to explain just how a differential works, but it's the damndest collection of gears you've ever seen. It's expensive. And hard to make in the extreme. But it lets inner and outer driven wheels to turn at their own speed with full driving torque applied to both. The thing to do is eliminate a single driven axle completely, and use two separate motor-wheel assemblies. If you power up one wheel, the robot will pivot on the dead wheel and make a shallow turn. If you power both motors but reverse one, the robot will do a smart about-face, rotating around its own center axis. Altogether you have eight discrete motions possible by using four bits of information to power up and/or reverse two DC reversible motors. This method is also much more suitable for digital control from the output port of a microprocessor.

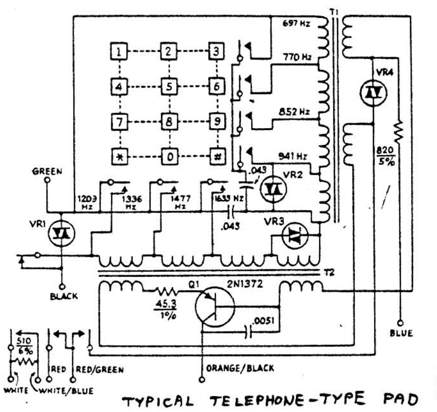
MOTOR DRIVING TIPS: What you want to do is use a MOS or CMOS output to drive a heavy current DC motor. A typical Cosmo-type robot will draw about four amps per motor. It's usually bad practice to pull more than 500 microamps from a MOS output. That means you're looking at an 8000 equivalent beta, at minimum for the driver transistor. In practice, we've found that you should set up a driver with two or three times that beta to make sure your power transistor is completely saturated while driving the motor at full speed. Anything less than full saturation will dip down into the power transistor's active region and dissipate enough heat to damage the transistor. Radio Shack has a power darlington in a TO-3 case which can handle (so they say) 15 amps. That's what I used in Cosmo's main motor drivers. Now, Radio Shack being what it is, you can usually expect them to overrate the betas on their transistors. Just to be safe, I drove the darlingtons with full spec 2N3904's having a guaranteed minimum beta of 100. This triple-darlington arrangement runs cool with motors going at full speed. The power darlingtons are heat-sunk with silicone grease against a black aluminum sink. Remember, always connect a heavy-duty silicon diode across a DC motor (reverse biased, of course) when driving such a motor from a transistor. When the heavy magnetic field in a motor collapses, as when the motor is de-energized, a high-voltage spike is formed which can destroy the junctions of even the huskiest power transistor. Since this spike is opposite the driven polarity of the motor, it shorts out through the diode. When using TTL logic in the vicinity, some .01 disks to ground also help.

RELAYS AND RELAY DRIVERS: What you want is a DPDT relay for each motor. A 12 volt coil is ideal if you're using a car battery; you just switch a ground to the relay with a transistor. A single 2N3904 will drive the small Radio Shack 12V DPDT relay from a TTL output. For driving from a MOS output, use 2 2N3904's in a darlington arrangement. The MPSA13 will also work, but it costs more. The little Radio Shack relay is a nice item; the coil draws only about 77 mils for good actuation. You might scrounge up other, cheaper relays somewhere; God knows they're around. Test them carefully to make sure you can drive them with one or two transistors. Put a diode across relay coils, too. They generate a spike just as motors do.

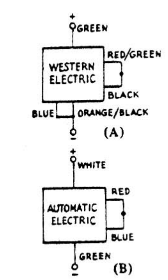
MOTOR DRIVE & REVERSAL CIRCUITS

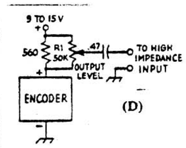


THE CARE AND FEEDING OF TOUCHTONE PADS: The TouchTone system is virtually ideal for robot radio control, because so much of the electronics can be had prefab, cheaply. Pads in particular can be had for about 20 bucks which are as big as a matchbox and draw scant microamps. We have gotten brand new Western Electric TouchTone telephone pads for as little as five bucks at hamfests. You just have to look around. Only God and the Phone Company know what all those multicolored wires are for, but we've figured out a few, enough to get them going. The diagrams say it all. If you're going to a hamfest you might want to rig a kluge test circuit to make sure the pad you're buying actually works. I bought one that didn't once. The pad will drive a speaker faintly all by itself, but the best thing to test it with, obviously, is a telephone earpiece transducer. That, a battery, and a resistor are all you need, as per the diagram. Lacking the transducer, a small speaker will do. Use the one with the higest impedance you can find. The big pads are bulky. There is an IC called the ME8900, made by Microsystems International, which contains everything to generate TouchTones on one oversize hybrid chip. It needs no crystal nor any adjustments, and currently can be had in surplus for seven bucks from Meshna and other places. Check your catalog file. If you don't have a catalog file, what kind of nut are you? The



TYPICAL TELEPHONE-TYPE PAD





ME8900, a couple of small electrolytics, and a Chomerics pad will give you cheap, small TouchTone input. Small button-pads with good touch-feedback (lacking on the Chomerics pads) can be had at hamfests for about ten bucks. They can't be beat for positive actuation and "feel." Do what your budget dictates. The best TouchTone generators are probably the CMOS versions, such as Motorola's MC14410P (which uses a 1.000 Mhz crystal) and the Mostek MK5086N, which uses a 3.579545 color-burst crystal (much less expensive.) My choice would be the Mostek. Buy it from Tri-Tek. These use so little power you can run them with a couple of those Polaroid SX70 film pack batteries torn (carefully) from discarded film packs. Two in series provide plenty of voltage and current. If they're too big, tiny 15V batteries can be had at Radio Shack for a small fortune. TouchTone pads are generally low-impedance output devices. If you intend to run them into a high-impedance mic input on a transmitter or amplifier, you'll have to use a matching transformer. Turn a transistor audio output transformer around, with pad to secondary (about 8 ohms) and primary to high-impedance input (about 2000 to 10000 ohms). This isn't critical. Most transistor radios have one or more such transformers. Try them all until you find one which works.

TOUCHTONE DECODERS: At this point there is only one good way to decode TouchTones: the 567/2567 PLL toner decoder IC. The 2567 is an EXAR product containing two 567's on one chip. Depending on who you buy it from, the 2567 may well be cheaper than two 567's. Check out your catalog file. The micropot sets the sense frequency of the PLL, which can be measured if you have a frequency counter from pin 6. Note that all sections are

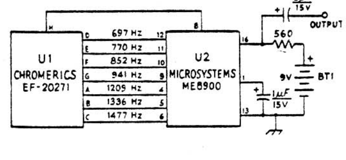
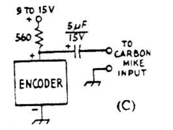
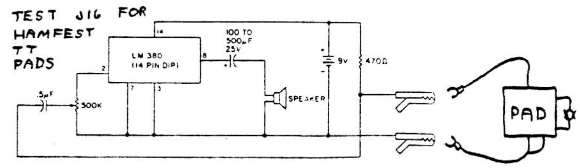


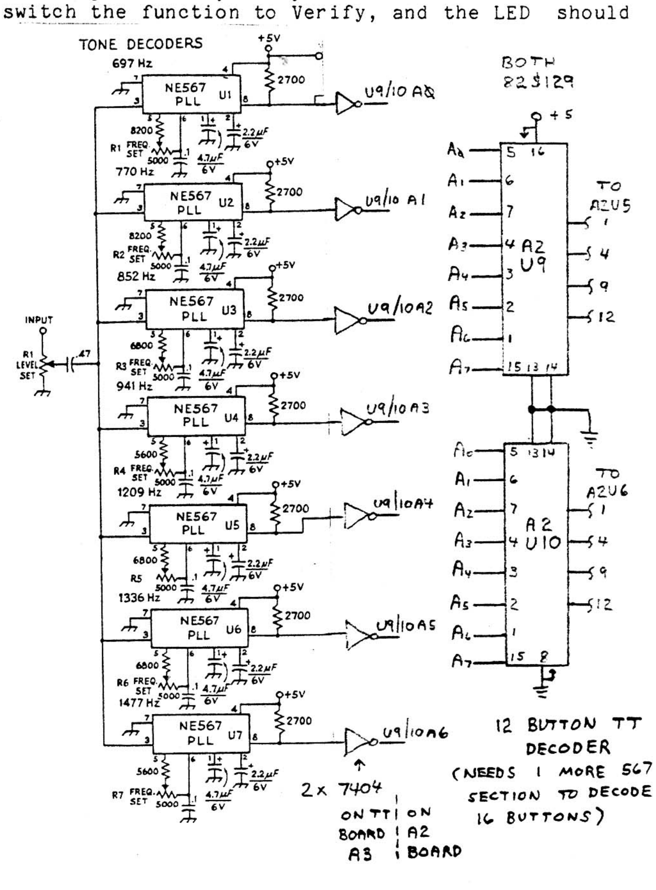
Fig. 8-15 — Circuit for a simple Touch-Tone encoder. The capacitors are electrolytic and the resistor is 1/4-watt composition.
BT1 — Miniature 9-V battery.
U1 — Chromerics EF020271 (See Fig. 8-14 for address).
U2 — Microsystems International ME8900 (Microsystems International, 800 Dorchester Boulvd., Montreal, Quebec.



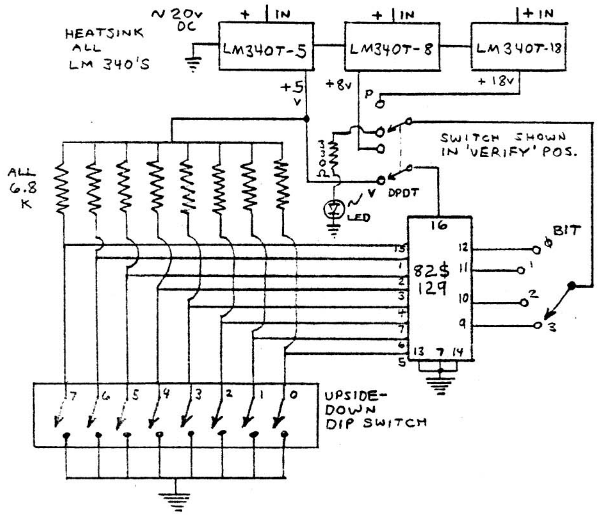


SEE ALSO

not identical. The resistor in series with the micropot sets the general sense range;use the wrong one and you won't be able to sense the proper row or column tone. The PC layout shown uses only seven PLL's and does not decode the fourth column tone, 1633 Hz. The board is repetitive and it should be no big thing to add an eighth 567 if you want that last column of buttons. The catch is, of course, that you will have to build your own 16 button pad. The board shown gives you two-of-seven switched outputs; that is, when a tone is detected, two 567's will switch and thus two of the output lines will go low. For most applications you'll want to decode that to give you a single switched output line, or perhaps several switched output lines for some robot control purpose. The way I did it, and the best way to go about it, is to use an 82S129 PROM. The PROM will do what all those gates do on the schematic diagram. You attatch the 567 output lines to the address inputs of the PROM; they provide the address where the desired switched output code is stored. The circuit of a suitable PROM-blower is also given. To use it, set your address (which will be the 567 two-of-seven code) into the DIP switch, put the function switch to Program, select the proper output bit to be programmed, and push the button once.A handful of milliseconds will program any bit; hold the button in longer and you may melt the whole row. Then switch the function to Verify, and the LED should



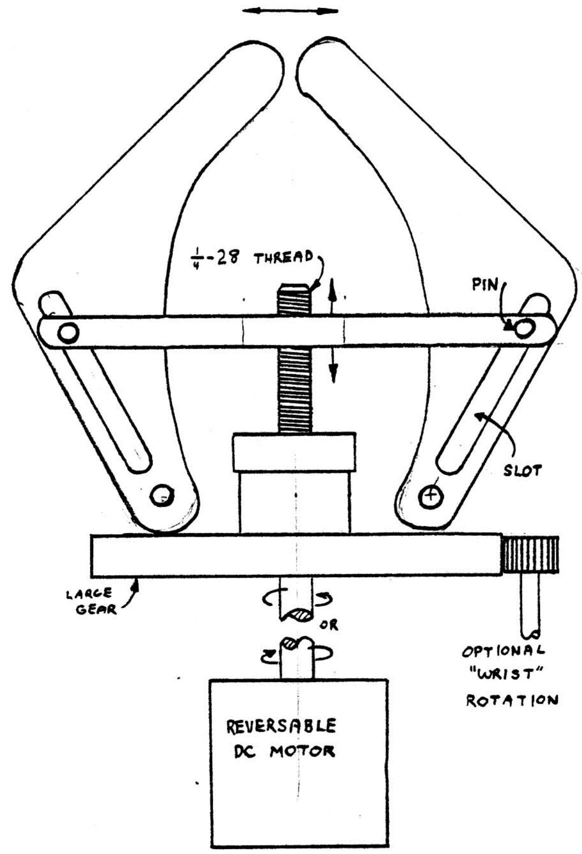
light for that bit, indicating that the programming was successful. Do the same for any other bits you wish to program. This PROM system is very handy when you want a given TouchTone to trigger two or three devices at once, say, the two drive motors and one of the reversing relays, to make the robot rotate about its axis. The chart shows the codes and bit patterns I used with Cosmo. These PROM's can be had from Digi-Key for $2.50 each, and they are well worth it.



82$129 PROM BURNER

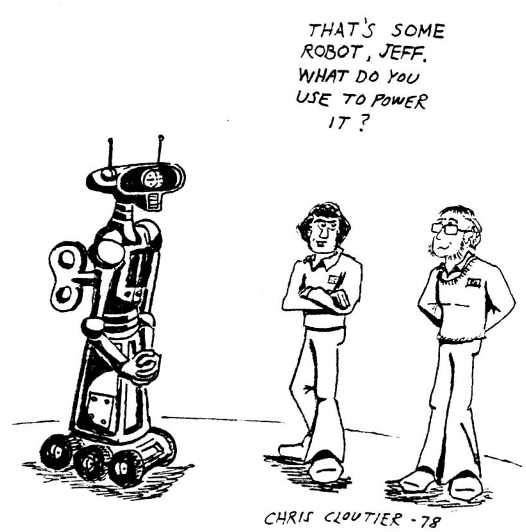
ROBOT COVERINGS: It's getting to be a fannish legend that GT robots are built in trashcans. Believe it or not, Joe was built before Star Wars was released. George Ewing had the can lying around, and Steve and Tullio built the robot inside it. Joe's marvellously tacky origins made him a fannish natural. I have my reservations about trashcans, since they're so tall and skinny. A better choice might be a small ribbed galvanized garbage can, especially one which has seen a little service. Scrub it out with some Lysol, but leave the dents. Even better from a weight and CG standpoint would be a small plastic garbage can. That leaves most of the mass in the battery and makes for more stability. Plastic also takes bumps and spills with more grace. A real artsy-craftsy techie could build up a covering from whole cloth using sheet aluminum and a pop riveter, or what the hell, maybe paper mache. Cosmo's little known last name, Klein, came from my intention to build him without any covering at all, with his bare insides hanging out. His insides would be the same as his outsides, just as with a Klein bottle... get it? I got so many requests to cover him up that I started in with black plastic, and I will admit, it's an improvement. (One young lady with remarkable pectoral development came up to me at Windycon 4 and said, "Put some clothes on him!" "Fine," I replied. "Give me yours." Cosmo remained blissfully naked.)

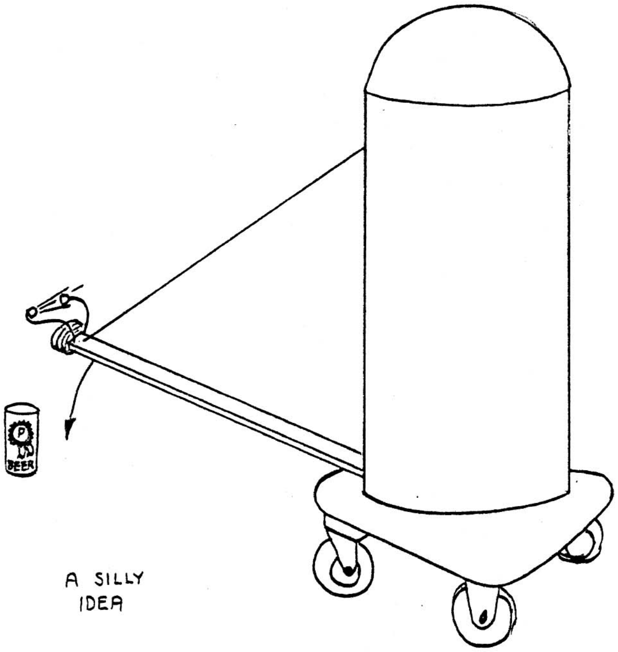
COSMO'S HAND: I'm not going to go into a great deal of detail on how to make hands and other manipulators for robots. This is supposed to be a tract for poor starving college kids, and I suspect that a basement full of machine tools are not standard equipment for most of you. I'm including some sketches to show generally how they work, and if you can handle machine tools you should be able to figure out how to make up something for yourself. This is a good place to point out that most schools having a physics department also have a machine shop somewhere; large schools with engineering departments probably have one helluva machine shop somewhere. It would behoove your poorer techies to make points with the men in charge of these operations, even if you're an English major or something worthless like that (like I was.) If you're an engineering student and you don't learn basic machine practice you're not getting a complete education. Many schools will offer remarkable unofficial fringe benefits to those who seek them out.



COSMO'S HAND 8/23/78

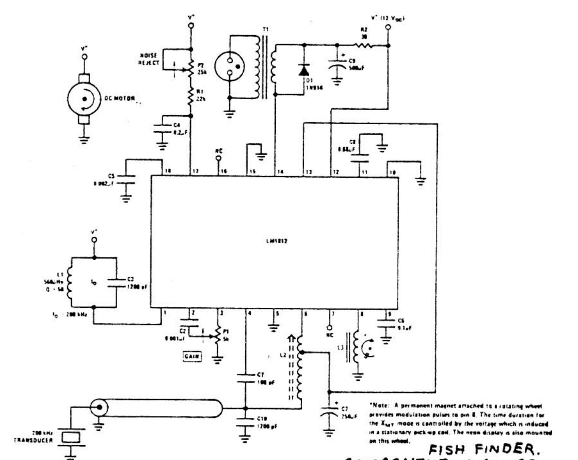
A SILLY IDEA: (But no sillier than your average politician and a lot less silly than commercial television) Wind yourself a husky electromagnet with #22 bell wire on a piece of half inch or three quarter inch iron rod. Mount it on a wooden or metal boom and run a string or preferably polyfilament line from the end of the boom to a small reversable motor with a long shaft. If you want to get fancy, rig a photoelectric sensor to either side of and slightly above the electromagnet, so that when the boom is lowered over a can of beer, the photocell will trigger a relay turning the magnet on. If your magnet has sufficient ass the robot can then lift the can and carry it back to you. Robot relay races are possible, although the magnet will probably get hot and warm the can of beer if the can is passed around from robot to robot. But that's the price you pay for a robot that does more than knock the ironing board over.





WHAT MICROCONTROLLER TO USE?: I chose RCA's COSMAC microprocessor family for a number of reasons. The most important (and probably the least relevant) reason was that it was a computer I could put together myself, and thereby learn something about computers. COSMAC has a number of other powerful advntages, however, and I must recommend it over any other microprocessor as a potential robot controller. It is an exceedingly low power device. With all the LED display chips pulled out of their sockets, my all CMOS system drew 25 mils running at 3.579 Mhz single phase. It will operate on a very wide range of voltages, from 4 to 14 volts on the premium version. It is very tolerant of poor power supply regulation. It has a very high noise immunity. It also has a very versatile I/O system which makes it a natural for dedicated controller applications. I've also found it to be easy to assemble on Vector board with a wire-wrap tool. The only other CMOS processor I know of is Intersil's 6100, which is a 12-bit PDP-8 lookalike and thus a poor choice for controller applications. If you're already very familiar with 8080 programming, you might be better off with the little 8085 controller board that comes finished and ready to run. PAIA has the 8700 dedicated controller, which also seems excellent for robots. I'm sure the KIM-1 would serve as well. In fact, almost any microprocessor evaluation kit computer would serve, since most are single-board simple systems that are cheap and easy to put together. If you want to go COSMAC but don't want to wire-wrap it, look into the ELF-II kit sold by Quest and Netronics. It's a mighty fine robot controller for about a hundred bucks. Whatever you buy, make sure it isn't tied down to some very particular form of input, like a teletype current loop. Toggle switches are fine; casette I/O is probably best, though I like paper tape better. At very least you'll need one output port and an input port. If the processor has one or more flag lines for inputting data you may do without the input port. COSMAC, for example, has four input flag lines and one output flag line--another heavy point in its favor. Buy all COSMAC devices from Quest.

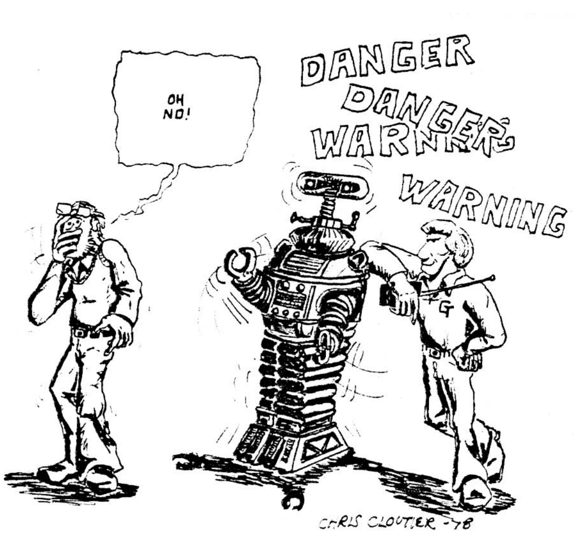
COSMO'S FACE: The idea of generating a face on a TV screen using video graphics techniques is, as far as I know, unique to my own Cosmo Klein. It's a natural due to the wonders of the COSMAC CDP1861 video generator chip. The 1861 was developed for RCA's now-defunct Studio One home video game line. It takes a 256 byte page of memory and maps it out on a TV screen with 1's as white dots and 0's as black spaces. This was invented to simplify generating a TV tennis playing field--your video buffer can be any 256-byte section of memory. What can be done for tennis can be done for a robot face. By storing the right patterns of 1's and 0's in memory a face will appear on the screen. By altering the bits in that page of memory, parts of the face can be made to move around. Your robot can blink, yawn, sneer, wiggle his nose, look sideways at pretty girls, or even lip-synch tape recorded speech by imposing sound-on-sound digital cues onto the tape recording. The COSMAC VIP (Video Interface Processor) by RCA is probably the best controller for face applications, but at $275 I'm not sure it's worth it. The ELF-II has the video chip, but not the extensive video software. For you COSMAC freaks, I've included a dump of Cosmo's face. Talking about animation techniques here would be a little too specific,since they would apply too narrowly to the COSMAC controller. It can be done, and if you're sharp enough, you'll be able to do it.



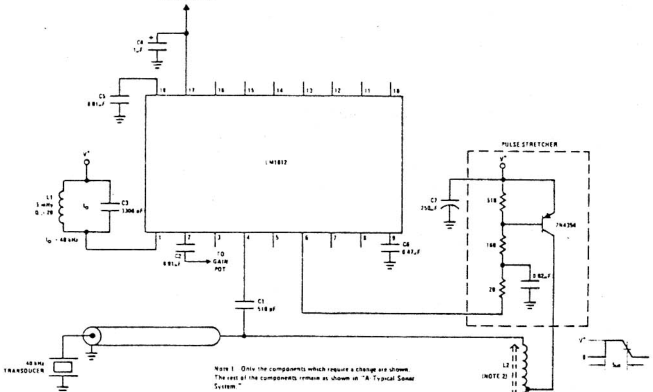
FISH FINDER. COMPONENT VALUES ARE FOR WATER USE.

A Typical Sonar Application

ROBOT SONAR SENSING: One of the basic tenets of the IC industry is that if there exists a mass demand for an electronic function, sooner or later some guy is going to put it on a single chip. Hence the vast array of color TV IC's--lotsa gold to be made there, sadly. I couldn't quite figure out what the mass need for an ultrasonic transceiver chip could be until I read the fine print in the specs: fish finder. National's LM1812 is a bizarre IC that sends out a sharp ultrasonic pulse and then listens for an echo. Upon hearing an echo it puts out a TTL-compatible signal. The poor fish don't have a chance these days. But to hell with fish; what we have here is ears for our robots. I think. I have an LM1812 and would have built a robot sonar system long ago, but the spec sheet shows a weird inductor as necessary for the circuit but won't give any specs on the inductor. Steve Johnson and I have been trying to figure it out, and if we do it will be no big thing to have a hand-held digital ranging



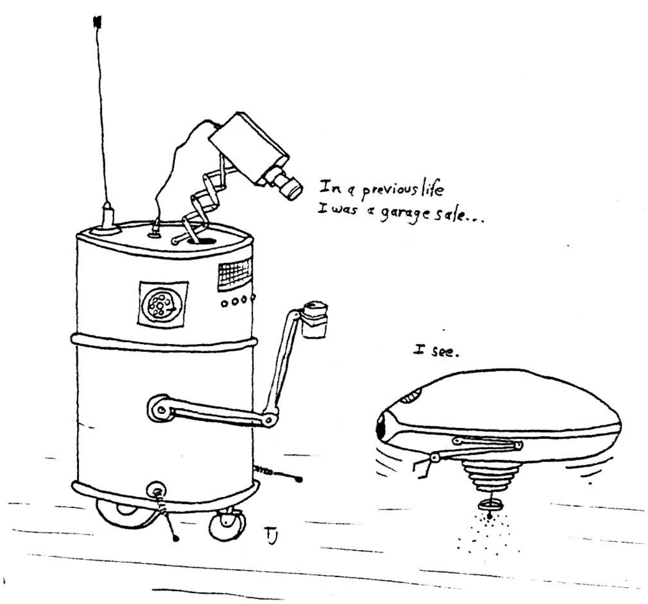
typical applications (con't)

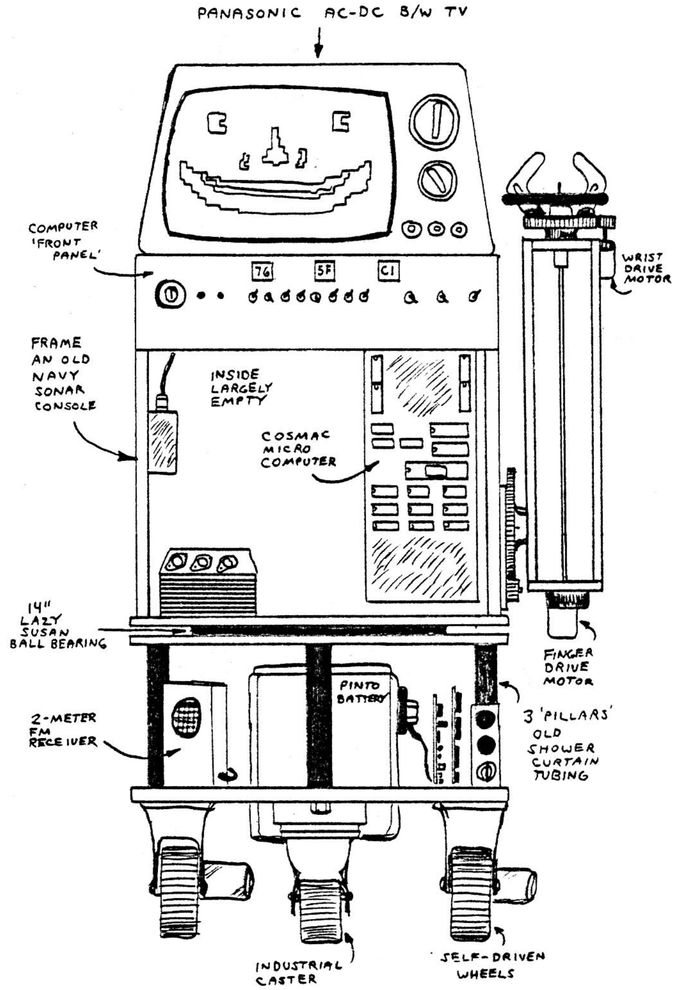


Component Changes for Operation in Air (40 kHz)

device that will tell you--in whatever units you choose--how far away the nearest big object is. How? Easy. You start the LM1812 with a pulse. This same pulse simultaneously starts a Mostek MK5002 running, which is a counter/latch/decoder/driver with the ability to count internally generated pulses. So while the 1812 is listening for an echo, the 5002 is counting its own pulses. Finally, when the echoe-pulse returns, the 5002 latch is strobed, saving some number of internal counts. This number can be jiggered by adjusting the speed of the internal count-pulses to tell you, in feet or inches or cubits or peppercorns, how far it is to the wall. With a stepper-motor driven horn atop the robot, the computer could aim the ultrasonic transducer any way it wanted, and by asking for a ranging at various angles, it could build up a continuous digital "picture" of the area it was in. By using a good avoidance algorithm, any processor could keep the robot from running into anything. Admittedly, the "resolution" of a sonar-generated world picture is pretty coarse, but there lies its sole advantage: it is easily interpreted by simple programs running in an uncomplicated micro. Video pattern recognition is <u>tough</u>. For more on the 1812 see <u>PE</u> July 1976.

IT MAY OR MAY NOT COME IN THE MAIL DEPT: In this Age of Impatience it's a pain in the ass to wait three weeks for the last part you need for a project, but since Radio Row has gone the Way of All Flesh, mail order is what we're stuck with. A little planning and some hard shopping can ease the pain. Try to anticipate your needs, and stagger your projects so that you can work on one while waiting for materials for another. Keep a catalog file! I don't mean maybe! Buy the latest issues of the top three or four electronic hobbyist magazines, and send off those funny little cards in back. <u>Circle as many numbers</u> as



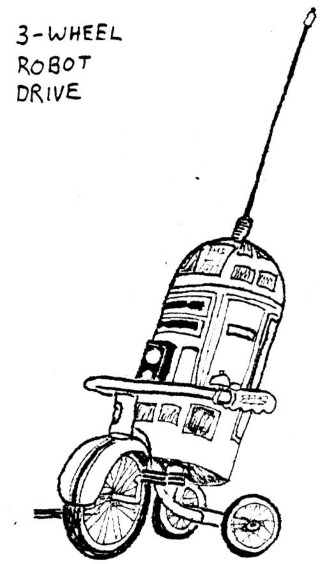


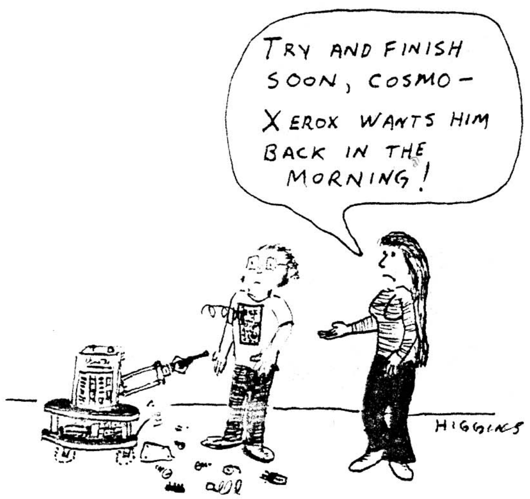
COSMO KLEIN

you're allowed. Many advertisers who ask for a quarter or more for a catalog will send it free if you use a reader service card, and any firm which charges for a catalog should be gleefully boycotted. I have yet to pay for a mail-order catalog, and I do just fine. Pray for junk mail. People who object to non-pornographic junk mail are hopelessly paranoid. Think of it as potential energy if you have a fireplace, or as sanitation material if you have a cat. Keep your catalog file current. Use a work address if possible, and companies will send you catalogs until twenty years after you're dead. Shop for the best price, especially on big-ticket items, but listen to the scuttlebutt and avoid marginal dealers who haven't learned how competitive the mail order biz is. Also avoid those moronic dealers who want two or three buck (one place charges 15% on <u>all</u> orders) "handling" charges. It's a signal <u>that</u> they aren't interested unless you want to spend a hundred bucks. Now, recommendations. Digi-Key takes all awards for promptness, prices, and service, with Quest a very close second. SD Sales, Tri-Tek, and Advanced Computer are neck-and-neck, and all excellent. James ships fast, but their prices are too high. Godbout's fine service is legendary, but I can't tolerate their prices. Life's full of tradeoffs. Avoid Poly Paks, Delta, MiniMicroMart, and Ace. Meshna is irregular. Fair Radio is slow but reliable. Nu-Tone is lightning-quick but leans heavily to Japanese transistors. Optoelectronics is good but not great. Under <u>no</u> circumstances buy from ETCO, Formula International, Active Electronics, Trinico, or Edlie's. If it's not here that means I have no data. You're on your own.

MESKLINITE ROBOT
-JD

USES FOR ROBOTS: Aside from attracting attention and egoboo for the builder, what good is a simple, scrunge-scrounge robot? I envision a wandering hors d'oerves table, programmed to carry a snack tray around a party room while avoiding objects and people as best it can. Assuming a partygoer could catch the robot, a tap on its whatever would stop it long enough to grab some caviar, and another tap would send it on its way again. It's no great leap after that to imagine putting a crockpot atop the robot for hot snacks or meatballs. The tap-function could be a simple touch-switch. In a similar fashion, a robot could pass out leaflets in a hotel lobby at a convention, perhaps saying "Please take one" to each person who gets in its way. I'd be wary of having a robot walk a dog unless I could be sure the robot would not run the dog over; Cosmo weighs upwards of eighty pounds. A dog too big to run over might well take the robot for a walk, and that isn't what dogs are for. In light of recent Big Apple ordinances, it might be worthwhile to devise a robot that could walk a dog and pick up dogshit as well. The biggest problem, I guess, is to teach it to pick up shit only from its own dog; in NYC an indiscriminate shit-gathering robot would be a veritable manure-pile in less than fifty yards. A properly outfitted vacuum cleaner could do a rug well just by randomly wandering around until the whole thing had been covered. Ditto for a lawnmower. The fiendish beasties from Jerry Lewis's 1962 potboiler "It's Only Money" come to mind. On second thought, what good is a robot? Nothing, obviously, and that is the whole damned point.

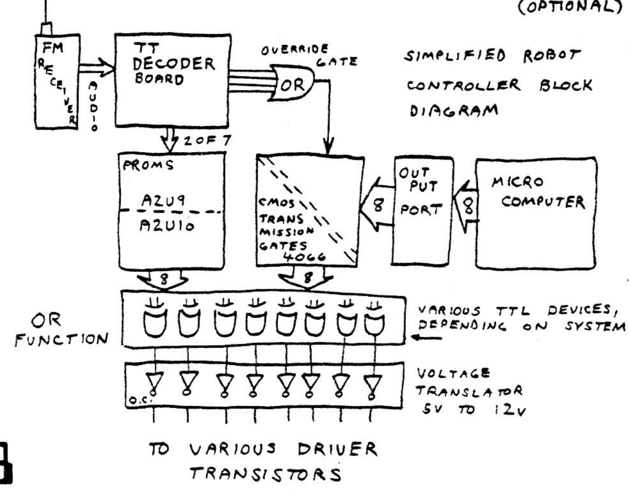




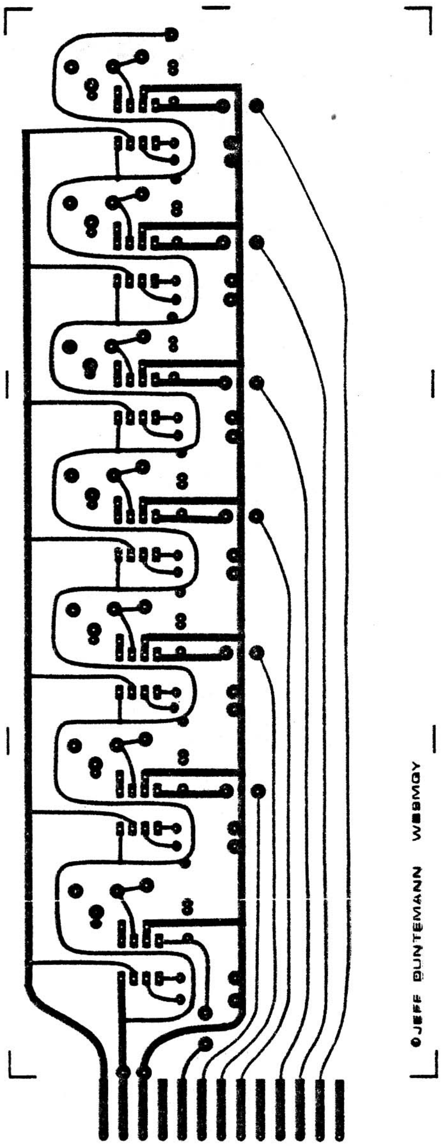
PROM TRUTH TABLE

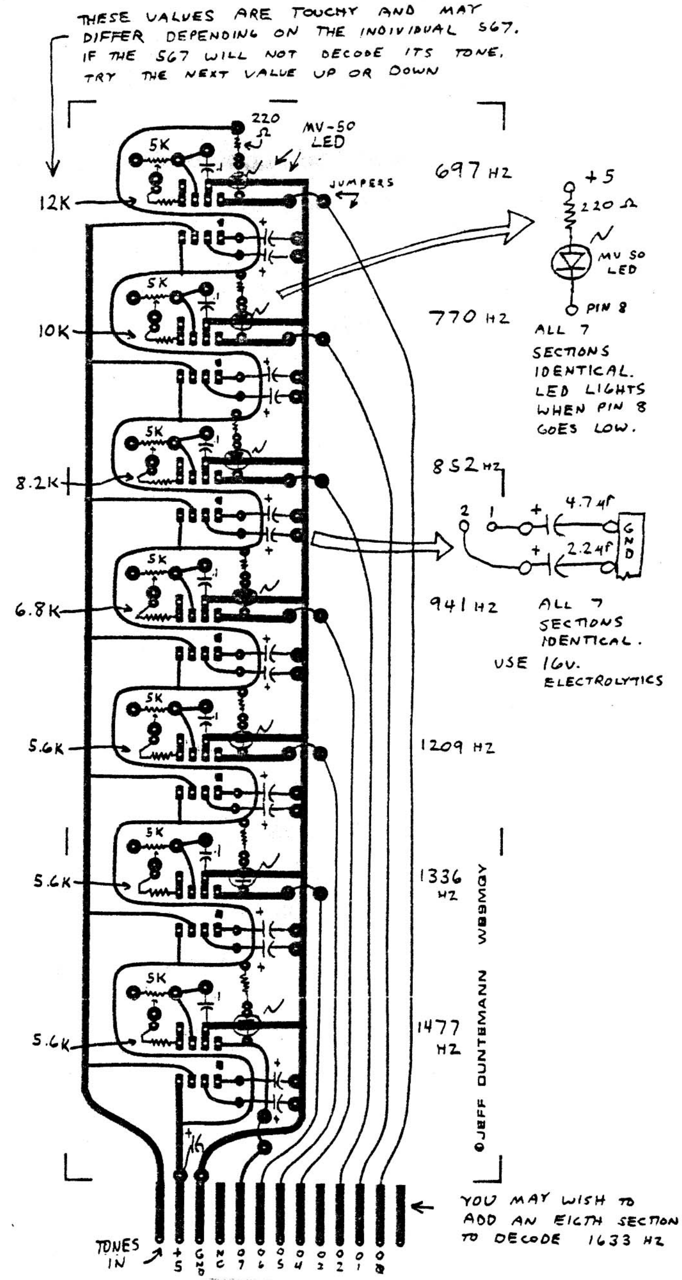
1 = HIGH

FUNCTION	TT #	PROM ADDRESS 7	6	5	4	3	2	1	0	A2U9 0	1	2	3	A2U10 0	1	2	3
LEFT TURN	1				1				1	1							
FORWARD	2			1					1	1		1					
RIGHT TURN	3		1						1			1					
ROT. LEFT	4				1			1		1	1	1					
REVERSE	5			1				1		1	1	1	1				
ROT. RIGHT	6		1					1		1		1	1				
ARM UP	7				1		1							1			
HAND OPEN	8			1			1								1		
ARM DOWN	9		1				1							1		1	
	*				1	1								AVAILABLE			
HAND CLOSE	0			1		1									1		1
	#		1			1								AVAILABLE			
		1633	1477	1336	1209	941	852	770	697	MOTOR 1	RELAY 1	MOTOR 2	RELAY 2	ARM MOTOR	HAND MOTOR	ARM RELAY	HAND RELAY
		TOUCHTONE OUTPUTS								MAIN DRIVES				HAND/ARM (OPTIONAL)			



AND FINALLY: Building robots is not easy. I never said it was. It can be hair-tearing, in fact, when you toggle in a new robot op system, start it up, and watch the damned thing sit there staring at you, inert as the shitcan you made it out of. Things do go wrong. Some people, especially those innocent of technical knowledge, believe that engineers draw something on paper, hand it to a machinist, and then forget about it; their work is done on paper, and works every time. What a laugh. The measure of the quality of a good engineer is how far ahead he can design successfully between breadboard stages. Mediochre engineers and us phony liberal arts engineers prefer to design by the seats of our pants. We try something, and if it doesn't work we shrug and try something else. Eventually we get where we're going, and the measure of our quality is how long it takes us to get there. The fun of it is in the going and the doing. Build a robot. Go ahead. I dare you. Look at it this way: if you build one and it doesn't work, it's already in the trashcan. Who said robots aren't labor-saving devices?





Pattern is shown from foil side. Note that this page has been reduced to 65% of its true size. This board does not include output inverters. Output from the 567's is low when a tone is sensed; otherwise the pin 8 outputs are held high. To eliminate confusion and to clean up the somewhat noisy output lines, Schmitt trigger inverters might be used.

GENERAL TECHNICS

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